Comparison of Photosynthetic Responses of Keanf (*Hibicus cannabinus*, C3-plant) and Napiergrass (*Pennisetum purpureum*, C4-plant) to Normal and Water Stress Conditions

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Introduction: Kenaf and napiergrass are known as a C3 and C4 species having an exceedingly high productivity and a well adaptability to environments, respectively. It is interesting that physiological or ecological characteristics in growth and production are clarified by comparing a high yield C3 plant like kenaf with a C4 plant, and the result obtained is considered to offer fundamental ideas for the improvement of production efficiency and growth stability in crops. In this experiment, we have conducted investigations with kenaf and napiergrass grown under the widely different soil-water conditions ranging from drought to the flooding in order to characterize the eco-physiological aspects of these species from the viewpoints of CO2 exchange and PSII electron transport.

Materials and Method: Kenaf (*Hibicus cannabinus* L., C3-plant) and napiergrass (*Pennisentum purpureum* Schumach, var. Marker, C4-plant) were pot-grown used as experimental materials. In order to accurately compare the response of two species, one plant of kenaf and one shoot of napiergrass were grown together in a 8-liter pot filled with sandy soil. The flooding treatment was taken by submerging the pots into a water tank for 1 week. After the treatment, the plants were grown in normal condition for 1 week and observed the recovery ability. The drought treatment was conducted by restricting water supply for two days, by which soil water potential were reduce to -1.95MPa. The recovery stage was three days. CO2 exchange rate (CER) and the related parameters were measured by using a sandwich-type assimilation chamber and CO2-H2O analyzer (Li 6262, Li-COR). Chlorophyll fluorescence was monitored with a fluorescence probe (PAM-2000, Walz) attached on the assimilation chamber.

Results: Under the normal condition, CER and stomatal conductance (Gs) of kenaf were high and stable during the sunshine time, while those parameters of napiergrass had a decreasing tendency toward the afternoon (Fig.1-A and -B). The maximum quantum yield (Fv/Fm) was neither affected by the flooding nor by the drought in both species (Table 1-A and-B). Under the flooding, little difference was found in gross photosynthetic rate (Pg), Gs and mesophyll conductance (Gm) and water use efficiency (WUE) between both species. While there was a significant specific difference in the recovery: Pg of kenaf showed a higher value than that of napiergrass. A better recovery of Gs in kenaf was a main cause of this (Table 1-A). C4 species are considered to be stronger in resistance to water deficits than C3 species, but here napiergrass showed a larger depression in Pg than kenaf under the drought. This was related with a large depression of Gs and Gm in napiergrass. WUE is also usually observed dominant in C4 species, but this parameter sharply dropped in napiergrass under the drought, while that of kenaf remained high. In addition, the recovery in kenaf was superior to napiergrass in most of the parameters (Table 1-B). The existence of photorespiration and increased NPQ in kenaf is the important photo-protection mechanism that allows C3-species plants to have a potential realizing a higher production with a better growth stability under varied environments than C4-sepcies like napiergrass (Table 1-A and -B).
Table 1. The responses of Pg, Gs, Gm, WUE, Fv/Fm, NPQ, ETR and Pr/Tc of kenaf and napiergrass under flooding (A) and drought (B) conditions. The measurements were taken under light intensity of 1000μmolm⁻²s⁻¹ PPFD condition.

A

<table>
<thead>
<tr>
<th></th>
<th>Pg</th>
<th>Gs</th>
<th>Gm</th>
<th>WUE</th>
<th>Fv/Fm</th>
<th>NPQ</th>
<th>ETR</th>
<th>Pr/Tc</th>
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<td>μmol m⁻²s⁻¹</td>
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<td>μmol mmol⁻¹</td>
<td>μmol m⁻²s⁻¹</td>
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<td>Control</td>
<td>16.7 (100)</td>
<td>0.23 (100)</td>
<td>70.2 (100)</td>
<td>4.5 (100)</td>
<td>0.83 (100)</td>
<td>1.52 (100)</td>
<td>156.7 (100)</td>
<td>30.0 (100)</td>
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<td>Kenaf</td>
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<td>0.19 (82)</td>
<td>60.7 (87)</td>
<td>4.7 (104)</td>
<td>0.83 (100)</td>
<td>2.03 (134)</td>
<td>154.1 (98)</td>
<td>34.5 (115)</td>
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<td>Recovery</td>
<td>15.9 (94)</td>
<td>0.20 (87)</td>
<td>56.4 (80)</td>
<td>4.2 (95)</td>
<td>0.81 (98)</td>
<td>1.72 (114)</td>
<td>151.7 (97)</td>
<td>32.0 (107)</td>
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<tr>
<td>Control</td>
<td>22.8 (100)</td>
<td>0.24 (100)</td>
<td>120.4 (100)</td>
<td>6.1 (100)</td>
<td>0.81 (100)</td>
<td>1.89 (100)</td>
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<td>Napiergrass</td>
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<td>5.9 (98)</td>
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<tr>
<td>Recovery</td>
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<td>90.3 (75)</td>
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<td>0.79 (98)</td>
<td>2.00 (106)</td>
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B

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<tr>
<th></th>
<th>Pg</th>
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<th>Fv/Fm</th>
<th>NPQ</th>
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<td>μmol m⁻²s⁻¹</td>
<td>%</td>
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<tr>
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<td>21.3 (100)</td>
<td>0.26 (100)</td>
<td>60.8 (100)</td>
<td>5.1 (100)</td>
<td>0.82 (100)</td>
<td>1.02 (100)</td>
<td>190.6 (100)</td>
<td>20.4 (100)</td>
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<td>Kenaf</td>
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<td>42.8 (47)</td>
<td>4.2 (82)</td>
<td>0.81 (99)</td>
<td>1.60 (160)</td>
<td>139.5 (73)</td>
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<td>68.5 (113)</td>
<td>4.1 (81)</td>
<td>0.83 (101)</td>
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<td>206.6 (108)</td>
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<td>Napiergrass</td>
<td>2.5 (1)</td>
<td>0.06 (31)</td>
<td>2.7 (1)</td>
<td>0.8 (10)</td>
<td>0.77 (96)</td>
<td>1.37 (121)</td>
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<tr>
<td>Recovery</td>
<td>19.7 (81)</td>
<td>0.19 (105)</td>
<td>139.1 (74)</td>
<td>5.6 (66)</td>
<td>0.79 (99)</td>
<td>1.24 (109)</td>
<td>130.5 (83)</td>
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Figure 1. Diurnal changes in CO₂ exchange rate (CER)-A- and stomatal conductance (Gs)-B- in kenaf (□) and napiergrass (□) under normal growth condition.